Vibrating RF MEMS in Diamond Structural Material

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Invited Paper Abstract

The increasing demand for secure, mobile, wireless communications has stimulated interest in technologies capable of reducing the size and power consumption of wireless modules, and enhancing the bandwidth efficiency of communication networks. With frequencies now in the GHz range and *Q*'s greater than 10,000, on-chip vibrating micromechanical resonators measuring only a few tens of microns on edge are now well positioned for inclusion into a number of future wireless communication sub-systems, from cellular handsets, to PDA's, to low-power networked sensors. The list of micromachinable materials used so far to implement such vibrating RF MEMS devices includes silicon (both single- and poly-crystalline), aluminum nitride, zinc oxide, silicon germanium, silicon carbide, and CVD diamond. Among this set, CVD nanocrystalline diamond shines as the material that (in combination with polysilicon support structures) presently holds the record for the highest frequency-*Q* product figure of merit (equal to 2.75×10^{13}) of any UHF resonator at room temperature [1]. Needless to say, that diamond's acoustic velocity is twice that of polysilicon is instrumental to achieving such impressive frequency-*Q* product performance.

In recent years, however, polysilicon resonators using loss-minimizing geometries (e.g., quarter-wavelength-supported extensional rings [2]) have begun to close the frequency-*Q* performance gap, to the point where diamond material is no longer needed to achieve the *Q*'s needed for the advanced communication architectures made possible by tiny high-*Q* resonators [3]. Nevertheless, CVD diamond remains a very important material for vibrating RF MEMS, mainly due to its likely amenability to fully planar, single-chip, post-CMOS integration with transistor circuits. In particular, the thermal budget required by diamond structural material might end up being much lower than that of polysilicon in post-CMOS integration processes, especially given recent examples of ultra-nanocrystalline films deposited at low temperatures, and given the likelihood that annealing will not be needed to improve material quality, as has been the case for polysilicon [4].

After giving a brief history of vibrating RF MEMS technology, its recent rapid progression, and the role that diamond material has played to date, this paper conveys some of the issues that presently plague planar MEMS/transistor integration processes and describes how the use of CVD diamond structural material might alleviate them.

References.

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